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The case of the circle leads to complicated results. The case of two fixed points is interesting. The equations of the intersecting straight lines may be written

$$y = \tan(\omega_1 t + \theta_1)x \dots\dots\dots(1), \text{ and } y = \tan(\omega_2 t + \theta_2)(x - a) \dots\dots\dots(2).$$

$$\text{From (1) } \tan\phi = \tan(\omega_1 t + \theta_1).$$

$$\therefore \phi = \omega_1 t + \theta_1. \quad t = (1/\omega_1)(\phi - \theta_1).$$

$$\therefore \rho \sin\phi = \tan(\omega_2 t + \theta_2)(\rho \cos\phi - a);$$

$$\text{whence } \rho = [a \tan(\omega_2 t + \theta_2)] / [\cos\phi \tan(\omega_2 t + \theta_2) - \sin\phi], \text{ or}$$

$$\rho = \{a \tan [\frac{\omega_2}{\omega_1}(\phi - \theta_1) + \theta_2]\} / \{\cos\phi \tan[\frac{\omega_2}{\omega_1}(\phi - \theta_1) + \theta_2] - \sin\phi\},$$

$$= \{a \sin [\frac{\omega_2}{\omega_1}(\phi - \theta_1) + \theta_2]\} / \{\sin[(\frac{\omega_2}{\omega_1} - 1)\phi + \theta_2 - \frac{\omega_2}{\omega_1}\theta_1]\} \dots\dots\dots(m).$$

If they both start from the initial horizontal position at the same time,

$$\theta_1 = \theta_2 = 0, \text{ and } \rho = a \frac{\sin[(\omega_2/\omega_1)\phi]}{\sin\{[(\omega_2/\omega_1) - 1]\phi\}}.$$

A large number of curves is included in equation (m).

This problem was also solved by C. W. M. Black. His solution will appear in the next issue.

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## MECHANICS.

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Conducted by B. F. FINKEL, Springfield, Mo. All contributions to this department should be sent to him.

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## SOLUTIONS OF PROBLEMS.

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41. Proposed by O. W. ANTHONY, M. Sc., Professor of Mathematics, Columbian University, Washington, D. C.

If the earth were a perfect sphere and had a frictionless surface, what would be the motion of a particle placed at a given latitude?

Solution by the PROPOSER.

Adopt as coördinates the latitude of the particle and the distance measured

in miles along a circle of latitude. Call the latitude  $\lambda$ , and the distance measured along the small circle  $x$ . Also let  $\lambda_1$  be the initial latitude.

As the particle moves towards the equator under the resolved component of centrifugal force there will be no acceleration parallel to the equator.

Then clearly,

$$x = 2\pi R(\cos\lambda - \cos\lambda_1) \dots \dots \dots (1).$$

Also for the acceleration towards the equator,

$$\frac{d^2(R\lambda)}{dt^2} = -\frac{2\pi^2}{T^2} R \sin 2\lambda, \text{ or } \frac{d^2\lambda}{dt^2} = -\frac{2\pi^2}{T^2} \sin\lambda.$$

Let  $d\lambda/dt = \mu$ .

$$\text{Then } \mu = \frac{\pi}{T} \sqrt{\cos 2\lambda - \cos 2\lambda_1}.$$

$$\text{Whence } t = \frac{1}{2} \sqrt{2} \frac{T}{\pi} \int_{\lambda_1}^{\lambda} \frac{d\lambda}{\sqrt{\cos 2\lambda - \cos 2\lambda_1}} = \frac{1}{2} \frac{T}{\pi} \int_{\lambda_1}^{\lambda} \frac{d\lambda}{\sqrt{\sin^2 \lambda_1 - \sin^2 \lambda}}.$$

Let  $\sin\lambda = \sin\lambda_1 \sin\phi$ . Then

$$t = \frac{1}{2} \int_{\phi_1}^{\phi} \frac{d\phi}{\sqrt{1 - \sin^2 \lambda_1 \sin^2 \phi}}. \quad \phi_1 = \frac{1}{2}\pi, \quad \phi = \sin^{-1}\left(\frac{\sin\lambda}{\sin\lambda_1}\right).$$

$$t = \frac{1}{2} \frac{T}{\pi} \left[ \int_0^{\phi_1} \frac{d\phi}{\sqrt{1 - \sin^2 \lambda_1 \sin^2 \phi}} - \int_0^{\phi} \frac{d\phi}{\sqrt{1 - \sin^2 \lambda_1 \sin^2 \phi}} \right]$$

$$= \frac{1}{2} (T/\pi) [F(\sin\lambda_1, \frac{1}{2}\pi) - F(\sin\lambda_1, \phi)] \dots \dots \dots (2).$$

Equation (1) gives the relation between the coördinates at any time, and (2) gives the time of motion.

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## AVERAGE AND PROBABILITY.

Conducted by B. F. FINKEL, Springfield, Mo. All contributions to this department should be sent to him.

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## SOLUTIONS OF PROBLEMS.

39. Proposed by O. W. ANTHONY, M. Sc., Professor of Mathematics in Columbian University, Washington, D. C.

A man is at the center of a circular desert; he travels at a given rate but in a *perfectly* random manner. What is the probability that he will be off the desert in a given time?